H. G. WEBSTER.

TELEPHONE SYSTEM.

APPLICATION FILED NOV. 27, 1908.

1,038,037.

Patented Sept. 10, 1912.

4 SHEETS—SHEET 1.

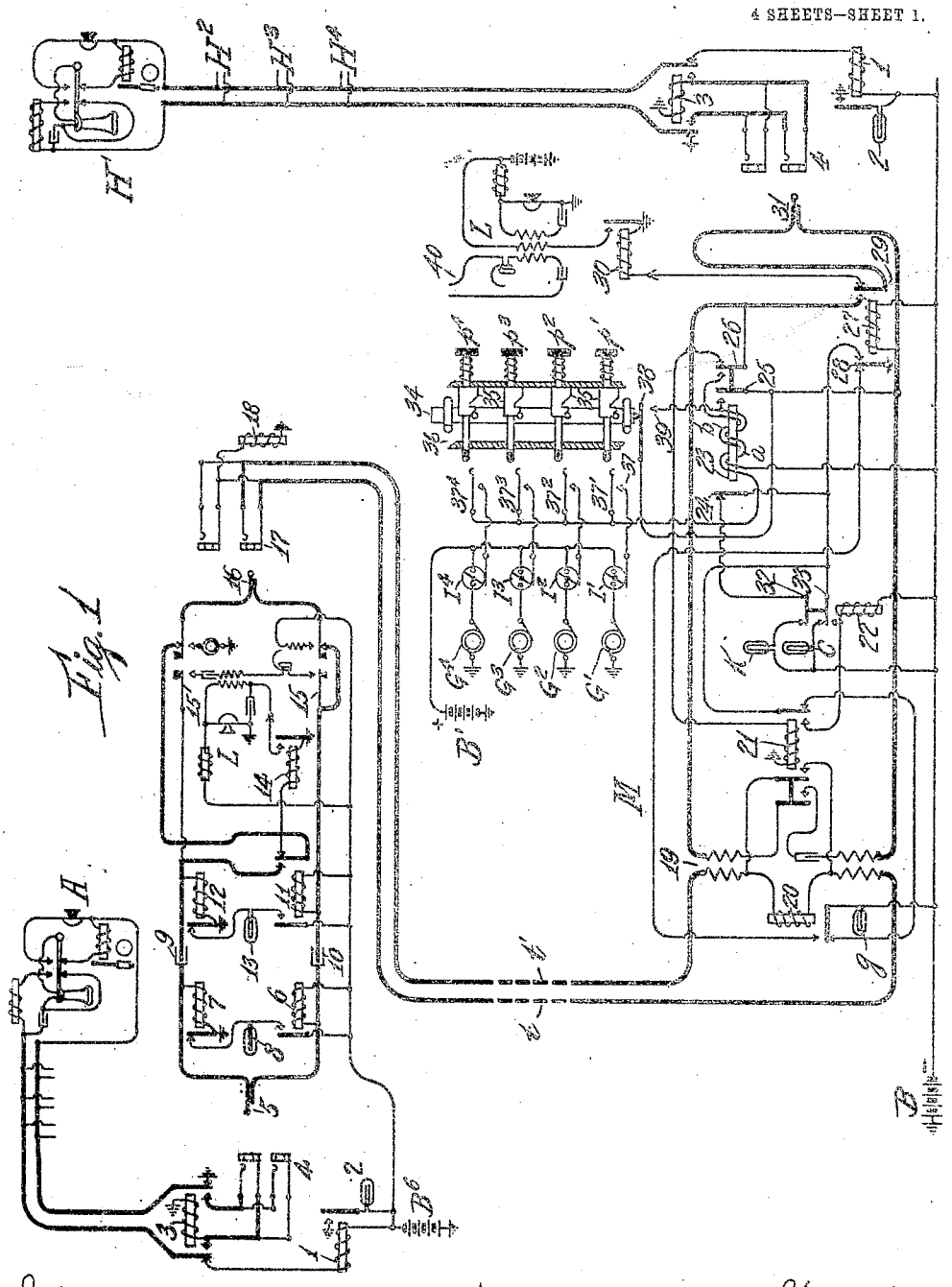

Fig. 1

Witnesses

G. E. Mueller

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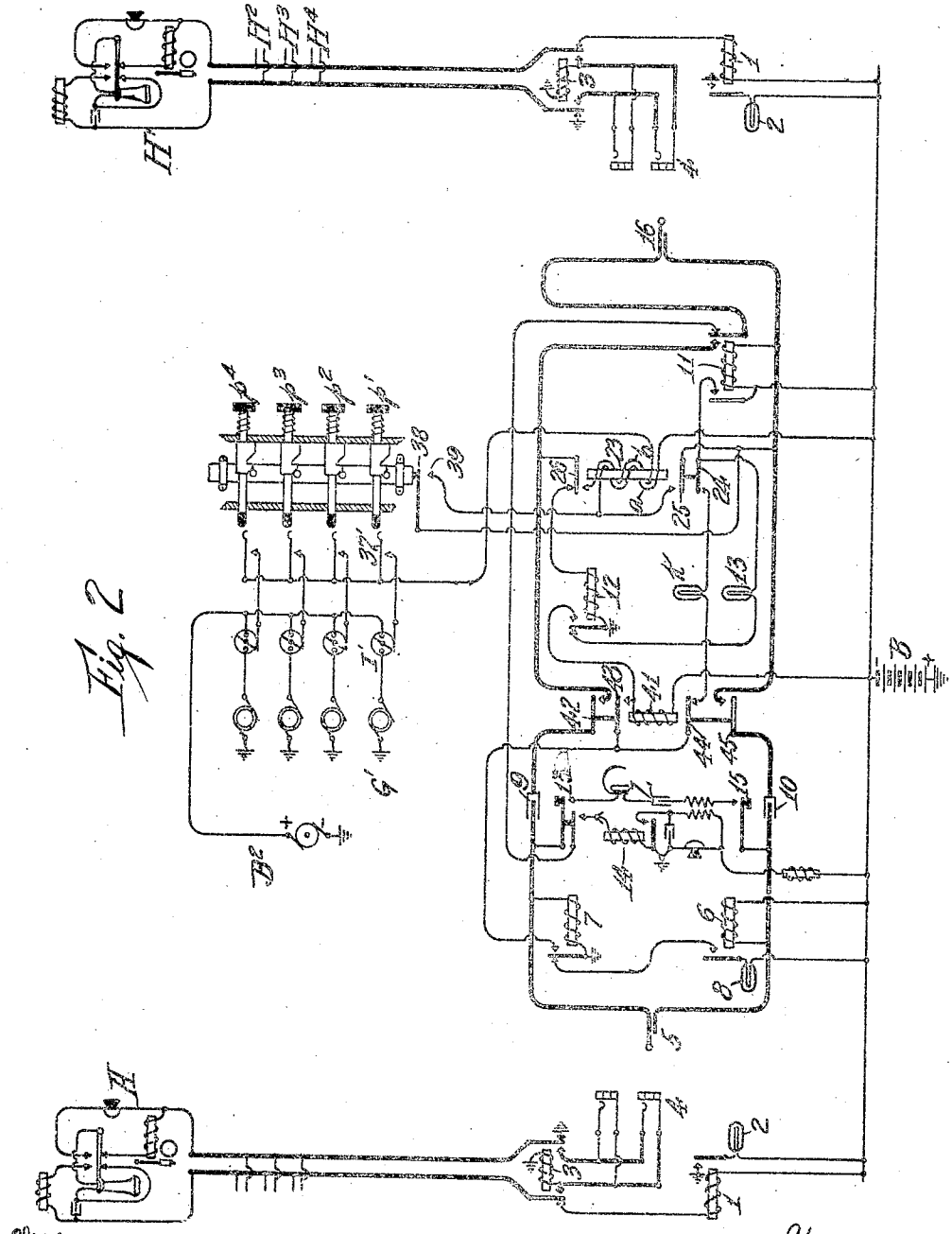

Fig. 2

Witnesses

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4 SHEETS—SHEET 3.

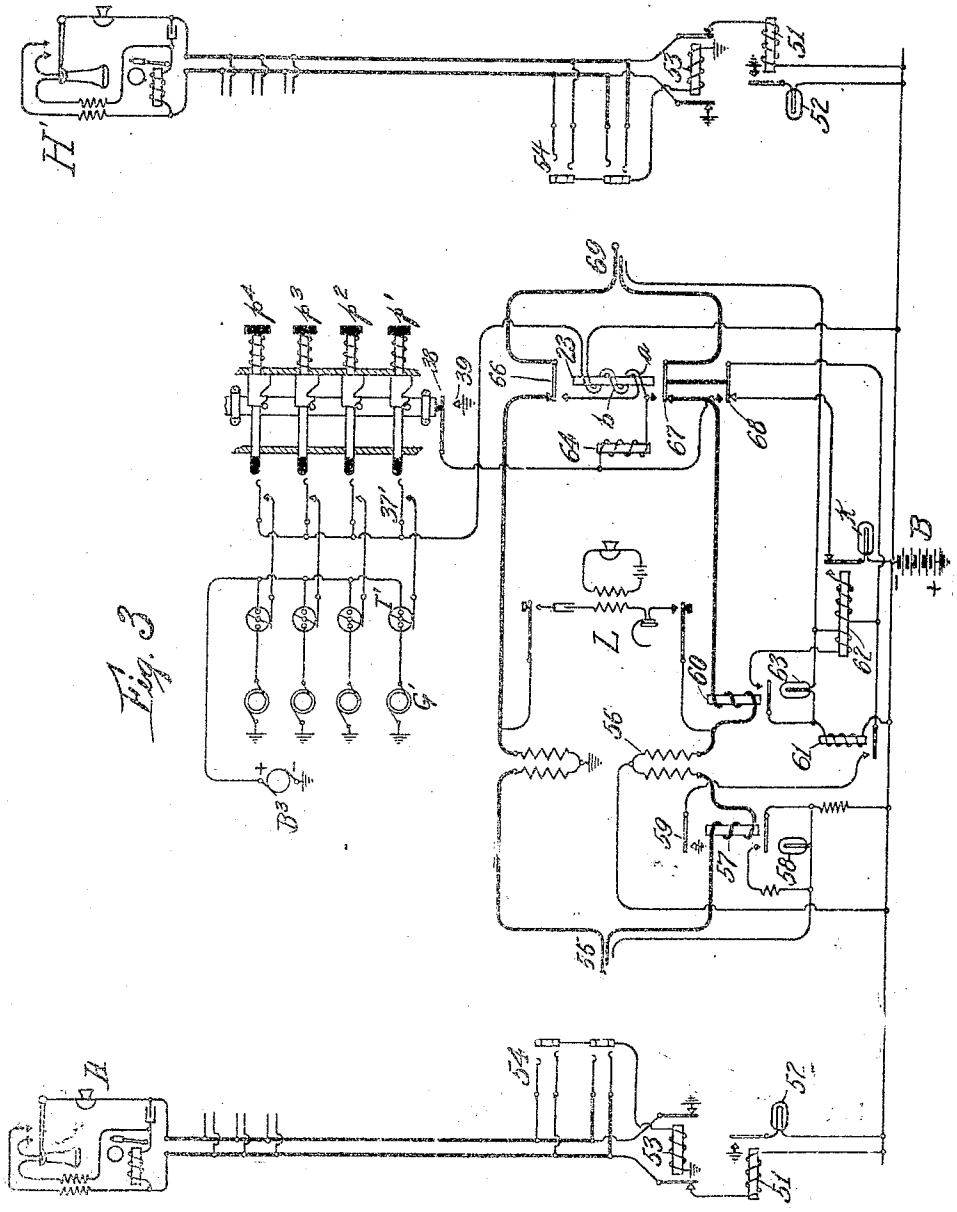


Fig. 3

Witnesses

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4 SHEETS—SHEET 4.

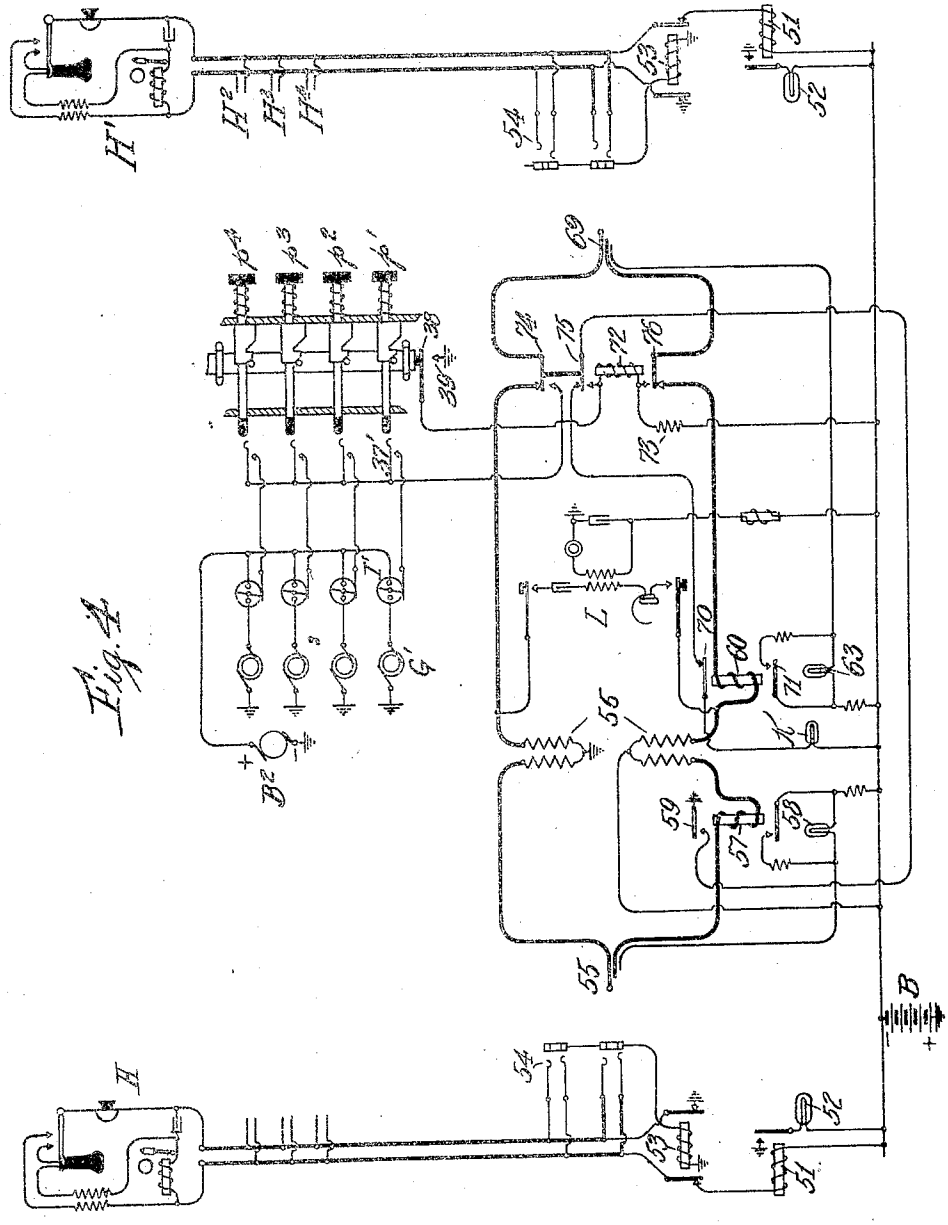


Fig. 4.

Witnesses

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# UNITED STATES PATENT OFFICE.

HARRY G. WEBSTER, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO KELLOGG SWITCHBOARD & SUPPLY COMPANY, A CORPORATION OF ILLINOIS.

## TELEPHONE SYSTEM.

1,038,037. Specification of Letters Patent. Patented Sept. 10, 1912.

Application filed November 27, 1908. Serial No. 464,577.

*To all whom it may concern:*

Be it known that I, HARRY G. WEBSTER, a citizen of the United States, residing in Chicago, county of Cook, State of Illinois, have invented new and useful Improvements in Telephone Systems, of which the following is a specification.

My invention relates to systems of a kind generally known as automatic ringing systems, the characteristic feature of which is found in the fact that ringing current is applied to a called telephone line to ring the telephone bell intermittently or continuously until the called subscriber answers, whereupon the act of answering serves to automatically terminate the connection of the ringing circuit with the line at whose substation response has been made.

The object of the present invention is to secure an improved and simple structure of the character described and is found in certain simplified circuit arrangements for controlling the current cut-off device for which I preferably employ an electromagnetic relay.

Referring to the drawings, I have shown in Figure 1 an application of my invention to a trunk cord-circuit adapted for use with a two-wire multiple switchboard; Fig. 2 shows an application of my invention to a local operator's cord for use in connection with a two-wire multiple switchboard; Fig. 3 shows a modified form of the invention applied to a local operator's cord-circuit for use in connecting subscribers' lines in a three-wire multiple switchboard; and Fig. 4 illustrates the invention applied to a local cord-circuit for connecting subscribers' lines in a three-wire multiple switchboard, the current-disconnecting relay being so arranged that but a single winding is required therefor, whereas in the preceding figures each such relay has two windings.

Referring first to Fig. 1, at A is illustrated a subscriber's substation circuit connected by a metallic circuit with the exchange and there provided with the customary line relay 1 which controls call signal 2, the cut-off relay 3, and the line jacks 4 of the line, of which a pair only are shown. A local operator's cord-circuit is illustrated, comprising the answering plug 5 and the calling plug 16 having tip and sleeve contacts, the tip contacts being connected by a suitable conductor in which is inserted the condenser 9, while the sleeve contacts are also connected together, having the condenser 10 connected in the conductor uniting them. Associated with answering plug 5, are the supervisory relays 6 and 7, controlling, as usual, the supervisory signal 8; while in association with the calling plug 16, are the supervisory relays 11 and 12, controlling, as usual, the supervisory signal 13. Suitable ringing key connections are illustrated, as are the listening-key levers 15, a test relay 14, and an operator's talking set indicated as a whole at L. The particular line and cord-circuits just referred to are of a character well known in the art and further specific reference to their arrangement is unnecessary. I have illustrated a pair of multiple trunk jacks 17 connected by suitable trunk conductors with a trunking operator's cord-circuit M which may be assumed to be at a distant exchange. This cord-circuit M includes the usual repeating coil windings 19 having the high resistance trunk relay 20 connected between the windings at the answering end of the cord, said relay 20 controlling the guard or disconnect lamp *g* in the usual manner. The signaling devices at circuit M include also a key lamp K arranged to warn the operator whether or not ringing current has been applied to the called line as hereafter explained, and the calling supervisory lamp C connected in circuit in such way as to advise the operator of the response of the called subscriber. The ringing relay 23 and the sleeve relay 27, associated with the trunk plug 31, are particularly concerned in the control of the ringing current. The relay 23 is provided with two windings, one, *a*, serving to operate the relay to cause the connection of ringing current to a connected telephone line, while the other, *b*, is so connected with respect to the winding *a* and a suitable source of energizing current as to serve at the proper time to prevent the continued efficacy of the winding *a*, in which operation the relay 27 contributes as an operative shunt of

the winding $a$ in a manner which will be more fully explained when the detailed circuits are described in connection with their operation.

The invention is adapted for use in connection with selective party line ringing and I have accordingly illustrated at the right hand of Fig. 1 a party telephone line having connected to it the substation H′, while taps at $H^2$, $H^3$ and $H^4$ indicate the connections of other substations similar to H′. The said substation may, as indicated, be provided with tuned harmonic bells of any of the well-known commercial types. The harmonic generators G′, $G^2$, $G^3$ and $G^4$, shown asociated with cord-circuit M, are arranged for connection with the cord strands by the operation of the ringing key plungers $p'$, $p^2$, $p^3$ and $p^4$. Thus if the operator depress plunger $p'$, the generator G′ will be connected to the cord and will project ringing current thereover and over any connected line of a frequency to ring a substation whose bell is attuned like that of H′. When plunger $p^2$ is operated to connect generator $G^2$ with the cord, ringing current will be projected to ring a substation bell attuned to the second frequency, and so for the plungers $p^3$ and $p^4$. Each plunger has an insulated end adapted to close a corresponding contact 37′, $37^2$, $37^3$ or $37^4$, and carries its respective rigid cam member 35, said cam members having suitable engaging pins upon the slidably movable rod 34 controlling the contact spring 38. Each generator G has its appropriate continuously rotating interrupter I divided into two segments, one segment of each interrupter being connected to its respective generator, while the other segments have a common connection extending to the battery B′ having its negative pole grounded. Further, each interrupter I has a brush connected to the alternate contact 37 of its appropriate generator. Thus, as any interrupter I rotates, it will alternately connect its respective generator G to the respective alternate contact 37 and then substitute for the generator the battery B′, this operation being continually repeated at intervals of a few seconds, whereby the customary periodic ringing is secured.

When any plunger $p$ is depressed, its cam 35 first shifts rod 34 downward sufficiently to free the cam of any previously depressed plunger whose spring will restore it to normal. The actuating plunger then closes its contact 37, and as the downward stroke is completed thereafter moves rod 34 still farther to close contact 38—39. The plunger $p$, after being fully depressed, is released by the operator, and its associated spring moves it backward to the "indicating" position, wherein the hook of its cam 35 holds it by engaging its associated pin on rod 34. At this time, the contact 37 will be closed, but contact 38—39 will be open, a momentary impulse through the latter being all that is necessary for the operation of the system.

In a complete system, there will of course be any required number of line circuits and the usual lesser numbers of local and trunk cord-circuits for interconnecting the lines.

Assuming subscriber A desires to talk with subscriber H′, the removal of the receiver at A operates line relay 1 to close circuit through and light line lamp 2, whereon the operator, answering, will insert plug 5 in an answering jack 4, relays 6 and 3 then operating in series by current over the sleeve plug and jack contact. The attracted armatures of relay 3 open the circuit of line relay 1 and lamp 2 is retired. Said armatures also connect relays 6 and 7 to the line limbs and relay 7 operates by current over the line, preventing at this time the display of supervisory signal 8. The operator, depressing levers 15, 15, learns that the calling subscriber wishes to converse with subscriber H′ in the distant exchange and by order wire, indicated at 40, advises the trunk operator at M of the number of the subscriber wanted. The trunk operator then assigns the trunk to be used, that one shown in Fig. 1, and the local operator inserts plug 16 into the trunk jack 17 before her. Relay 11 then operates by current to ground through impedance 18, and the supervisory lamp 13 is accordingly displayed and the tip cord strand is completed. Current also finds its way through relay 11, sleeve contact at 16, 17, wire $t$, trunk relay 20, of high resistance, say, five thousand ohms, returning over wire $t'$ and to ground through relay 12, which latter, however, because of the resistance at 20, fails to operate at this time, allowing lamp 13 to continue lighted. Relay 20 at M, however, operates and displays guard signal $g$ by current to ground at normal contact 28, unless the trunk operator has already inserted plug 31 in jack 4 of the called line. Before doing so, the operator tests the called line in the usual way, the common test relay 30 being provided for the purpose.

Assuming the called line idle, the insertion of plug 31 in a jack thereof operates relays 27 of the cord and relay 3 of the called line in series by current from battery B to ground over the sleeve plug and jack contact. Relay 3 then connects the line limbs of substation H′ to the jack contacts, while relay 27, by armature 29, completes the tip cord strand and, by armature 28, opens a contact in the circuit of guard lamp $g$, putting it out, and closes a contact in the circuits of lamps K and C, which both light. The operator at M now actuates plunger $p'$ to connect the proper frequency

generator G′ and, as previously mentioned, such actuation results in a continued closure of contact 37′ and a momentary closure of contact 38—39. The closure of the latter contact energizes relay 23 by current from ground at relay 3 of line H′, over the sleeve cord strand, contact 38—39, winding *a*, and to negative battery at B, it being observed that relay 27 is in shunt of this circuit. Relay 23, by armature 25, locks itself to the sleeve cord strand and, by armature 24, puts out lamp K, whereby the operator knows that the relay 23 has properly operated and that the called subscriber is being rung up. Obviously, had the operator failed to actuate plunger *p′* completely to close contact 38—39, the continued display of the key lamp K would warn her of the fact. Owing to the attraction of armature 26 and the closure of contact 37, the interrupter I′ now avails to alternately connect generator G′ and positive battery at B′ through winding *b* of relay 23, alternate contacts 26 and 29 and the tip plug and jack contact with the limbs of line H′, across which the harmonic ringers are bridged as before described. Until a response is made at the called station, current from source B′ is ineffective because of the substation condensers. Generator current from G′ is, however, effective and passes through the four substations in parallel, actuating the bell at H′ only. The return path of said generator current is traced through sleeve contact at 4—31, through alternate contact 25, winding *a*, and to ground through the circuit of battery B. Since the two windings of relay 23 are unidirectional, the alternations from generator G′ have no operative effect upon the position of the relay armature mechanism, the said relay being practically differential or non-inductive to such alternations. The shunting effect of relay 27 upon winding *a* is, so far as concerns the generator alternations, negligible, since relay 23 provides a relatively non-inductive path for such alternations, while relay 27 is of course of considerable inductance. Therefore, since the alternating currents in windings *a* and *b* are practically of like quantities and opposed, the presence of the generator connection has, during ringing, no effect upon the core of said relay that need be taken into account, the relay remaining energized by the steady current from B through winding *a* and attracted armature 25.

Now assume that answer is made at H′ in the "silent interval," *i. e.*, when interrupter I′ has the positive pole of battery B′ connected to spring 37 and winding *b*. The removal of the receiver at H′ causes the two line limbs to be conductively bridged via the upper hook-switch contacts so that current from B′ flows through winding *b*, alternate contacts 26 and 29, tip contacts at 31—4, over a line limb through impedance coil, hook-switch and transmitter at H′, back over the opposite line limb, sleeve contacts 4—31, then branching, part of the current flowing through relay 27 and to ground through battery B, while the rest flows through alternate contact 25, winding *a*, battery B to ground. In this connection, it will be observed, first, that the removal of the receiver at the substation creates a somewhat heavier flow of current in winding *a* than previously existed and that the flow therethrough is in the same direction as before; second, that the current through the winding *b* is in a direction to tend to induce polarity in the core of relay 23 opposite to that induced by winding *a*.

The current through winding *b* will have as a minimum enough effect to neutralize the effect of winding *a* upon the core of relay 23 sufficiently so that the relay's armature mechanism will be retracted. The arrangement may be such that if the cord is connected with one of the telephone lines of the highest resistance, the current through winding *b* will, on response, approximately neutralize the effect of winding *a*, whereby the armature mechanism will restore. Then if the cord were connected with some line of relatively low resistance, the response might occasion a flow of current through winding *b* of sufficient volume, if continued, to reverse the core polarity and build up in the opposite direction. However, when in the case of such short line, the current through winding *b* has endured a sufficient time so that the core is about neutral, the armature mechanism instantly restores, opening the circuits of both windings, so that the relay will protect itself against being continued locked by the building up of a reversed polarity in its core. Obviously, the arrangement is adapted for use with lines having very wide resistance differences.

Excellent results may be obtained over lines of widely differing resistances by making the two batteries B and B′ each of twenty-four volts, each of the windings *a* and *b* one hundred and sixty ohms, the winding of relay 27 of one hundred ohms, and those of cut-off relays 3 of the lines five hundred ohms. However, these characteristics may be varied, the only limiting restriction being that the winding *b* oppose the winding *a* sufficiently to release the armature mechanism at the proper times.

The response at substation H′ has accordingly modified the magnetization of the core of relay 23 to an extent causing the retraction of its armature mechanism.

Circuit through both windings of relay

23 being now opened, the relay remains inert. The closure of normal contact 26 causes relay 21, which may have one hundred ohms resistance, to operate by current through substation H′, and said relay, by its left-hand armatures, establishes the talking circuit at repeating coil 19, one of said armatures shunting the five thousand ohm relay 20 so that sufficient current will flow through relay 12 at the local cord to actuate its armature, whereby supervisory signal 13 is retired and the local operator advised of the response. Further, relay 22, which may be of five hundred ohms resistance, operates by current through the attracted right armature of relay 21, flowing to ground through the alternate contact 28, and locks via alternate contact 33. The opening of normal contact 33 puts out calling lamp C so that the trunk operator is advised of the response. Calling subscriber A and called subscriber H′ are now in conversation, the substation transmitters being energized by the central batteries. When subscriber A replaces his receiver, the circuit of relay 7 is opened and signal 8 is displayed. When subscriber H′ replaces his receiver, the circuit of relay 21 is opened, the relay's armatures retract, and the low resistance shunt about relay 20 is opened so that the current through relay 12 at the local cord is diminished to a point where its armature retracts to display signal 13. Both signals 8 and 13 being now displayed, the local operator withdraws plugs 5 and 16, restoring to normal the calling line and the local cord. The withdrawal of plug 16 deënergizes relay 20 and its armature lights guard lamp $g$ by current through normal right-hand switch contact of relay 21, alternate contact 28 to ground. The display of the signal $g$ while K and C are undisplayed warns the operator to withdraw plug 31, which act restores the called line and cord M to normal. As before stated, whichever plunger $p$ has been depressed will remain in the indicating position until another plunger is depressed. It will be seen that owing to the joint control of lamp $g$ by relays 20 and 21, and the fact that when one is energized the other is deënergized, the operation of lamp $g$ as a disconnect signal by current to ground at alternate contact 28 will only take place when plug 16 is withdrawn.

If the response is made at the called station H′ during a ringing interval, the current which then flows will also operatively affect the relay 23 to deënergize it, owing to the altered resistance at the substation, the generator current will at some period of its alternations substantially neutralize the core of the relay 23.

The connections shown in Fig. 2, applying my invention to a local cord-circuit in a two-wire system, are in general quite similar to those of Fig. 1. Here the relay 23 is associated with the calling plug 16 of the local cord and the sleeve supervisory relay 11 serves for the shunt for winding $a$ and in the control of key lamp K. In the present case, I have substituted a direct current generator $B^2$, having its negative pole grounded, for the battery B′ of Fig. 1. The mechanisms associated with plungers $p$ in Fig. 2 are the same as those of Fig. 1 and operate in like manner.

In Fig. 2, the subscriber A initiates his call and the operator answers as in Fig. 1. Learning the number of the called line, she tests her multiple jack of that line, the test relay 14, provided for this purpose, being in this instance adapted for connection with the tip plug contact by the operation of the listening key. Finding the line of H′ idle, the operator inserts plug 16 in a jack 4, which act energizes relays 11 and 3 in series, and she then actuates the proper plunger $p$ to supply ringing current of the required frequency. As before, momentary closure of contact 38—39 operates relay 23, establishing a flow of current from ground through cut-off relay 3 of the called line, sleeve contact 4—16, thence in shunt of relay 11, through contact 38—38, winding $a$ to negative battery at B, whereupon armature 25 locks the relay 23 to maintain it operated. As before, armature 24 puts out key lamp K, and armature 26, being attracted, connects the ringing current with the tip of plug 16 and so to the called line circuit, via the attracted right armature of relay 11. If response is made in the silent interval, current from positive pole of $B^2$ flows through 1′, 37′, $b$, in a direction to induce magnetism to oppose the magnetic effect of winding $a$, over the called line and back to ground through the circuit of battery B, the return circuit including parallel paths through relay 11 and winding $a$. The core of relay 23 is by this current affected to release its armature mechanism, which restores to normal. The closing of normal contact 26 operates relay 12 by connecting it with the called line. The attracted armature of relay 12 puts out lamp 13 which was displayed from the time the operator connected with the called line to cause the attraction of the left armature of relay 11. By such putting out, the operator knows that the called subscriber has answered. Further, the attraction of the armature of relay 12 operates the closing relay 41 which, by armature 43, locks to ground at the attracted armature of relay 7, by armatures 42 and 43 completes the talking circuit at the cord, and by armature 44 prevents redisplay of key lamp K. When at the conclusion of conversation, subscribers A and H′ replace their receivers, they deënergize respectively relays 7 and 12, to display the signals 8 and

13. When both are displayed, the operator withdraws plugs 5 and 16, restoring the line circuits and the cord-circuit to normal. The locking contact 43 of relay 41 has its circuit controlled by the armature of relay 7 in order that, if both subscribers depress their hook-levers, the relay 41 may unlock and deënergize. Assuming that subscriber H′ prematurely replaces his receiver and subscriber A wishes the operator to again signal substation H′; subscriber A will depress and elevate his hook-lever a few times, thus "flashing" lamp 8 to secure the operator's attention. The first depression of the hook-switch will, by deënergizing relay 7, cause deënergization of relay 41, which then remains deënergized, until the operator has, at the calling subscriber's request, again actuated the proper plunger to ring the called subscriber and the latter has responded. By the arrangement mentioned of relay 41, key lamp K is brought operatively into the operations when a called subscriber has to be rerung, and during the reringing the cord is opened at 42, 45, so that ringing current cannot reach the calling line. In the present instance, battery B, having its positive pole grounded, may be of one hundred volts, windings *a* and *b* may be each of one hundred and sixty ohms, the windings of relays 11 and 12 of one hundred ohms each, while the windings of the cut-off relays 3 of the lines may have five hundred ohms resistance. While other values may obviously be assigned, the above give excellent results. In the present case, response during the ringing interval also releases the relay 23, as explained in connection with the previous figure.

In applying my invention to a three-wire system, shown in Fig. 3, a somewhat different arrangement from those previously described is employed. Here, upon the actuation of a plunger *p*, the closure of contact 38—39 connects the energizing winding *c* in series with the impedance 64 from ground at 39 to negative battery B, whereafter the attraction of armature 68 continues current through 64 and *a* from ground at 59 and through the armature of 61. The winding 64 is, however, in shunt of winding *a* with respect to the circuit extending from the ringing key through the contact 37, winding *b*, over the limbs of the called line H′ and back to armature 67, so that when, on the response, direct current from source $B^3$ flows over the line, said impedance 64 serves in adjusting the current flow in winding *a* so that the required magnetic effects upon the core of relay 23 are secured. In calling, subscriber A removes his receiver, energizing relay 51 which lights lamp 52, in response to whose signal the operator connects plug 55 with a springjack 54, thereby connecting the heavily marked talking conductors of the cord with the line limbs, so that current circulates from B, through relay 57, over the line limbs, and returns to ground through the left upper winding of repeating coil 56. The armatures of relay 57 thus attract, the lower one shunting supervisory lamp 58 to prevent its display at this time. Over the third plug and jack contact, relay 53 receives current from battery B and its armatures deënergize relay 51, so that signal 52 is retired. The operator connects her listening set L and learns that subscriber H′ is wanted. Assuming the usual test shows the called line to be idle, she inserts plug 69 in a multiple jack 54 of the called line, when current will flow from ground at cut-off relay 53 of line H′, through sleeve plug and jack contact, lamp 63, relay 61 to negative battery B. Supervisory signal 63 is accordingly displayed and relay 53 operates to disconnect line relay 51. Relay 61 also operates, whereon a circuit may be traced from ground at 59, armature of relay 61, normal contact 68, key lamp K to battery, whereover current flows, lighting lamp K. As above indicated, when now the operator actuates plunger *p′*, relay 23 energizes and attracts its armatures, whereof 68 establishes the maintaining circuit for winding *a*, extending to ground at 59. As long as the substation switch remains depressed, the current alternations from the ringing generator will have no operative effect upon the armature mechanism of relay 23, since the windings are disposed to be substantially non-inductive to the ringing alternations, and impedance 64 forces by far the greater part of such currents to find their return through the winding *a* to battery B. If the subscriber responds in the silent interval, the current from generator $B^3$, having its negative pole grounded, flows through winding *b* over the line limbs, through the raised hook-lever at substation H′, returning to the attracted armature 67, and over parallel paths through windings 64 and *a*. Sufficient current will traverse the winding *b* in a direction tending to neutralize the magnetic effect of winding *a* to cause the relay 23 to permit the retraction of its armature mechanism. The retracted armatures of the relay 23 place both its windings on open circuit. Armatures 66 and 67 close circuit as follows: from ground, through the upper right-hand winding of repeating coil 56, contact 66, tip plug and jack contact 69—54, the hook-lever and transmitter at H′, returning through the sleeve talking contact at 54—69, normal contact 67, supervisory relay 60, and to negative battery B. Relay 60 attracts its armature to retire supervisory signal 63 by connecting the low resistance winding of relay 62 in shunt of said signal. Relay 62 accordingly operates and attracts its armature, locking itself in series with the

lamp K to ground at 59. Assuming the lamp K to be an ordinary twenty-four volt switchboard lamp, and the right winding of relay 62 to have a resistance of, say, five hundred ohms, the lamp K will be extinguished at this time so that the retraction of armature 68 does not cause a renewed display thereof. When the subscribers at A and H′ replace their receivers, they deënergize, respectively, the supervisory relays 57 and 60, whose retracted armatures remove the shunts from supervisory signals 58 and 63, which are displayed, warning the operator to withdraw the plugs 55 and 69. Upon the withdrawal, the line circuits and the cord-circuit will be at normal. If the subscriber H′ prematurely replaces his receiver, and subscriber A, by depressing and elevating his hook-switch, thus flashing lamp 59, signals the operator and asks her to ring subscriber H′ a second time, the depression of the hook-lever at A will, by deënergizing relay 57, have caused the locking circuit of the right winding of relay 62 to be opened, whereby said relay deënergizes and key lamp K is brought into operative relation with the ground at 59 as soon as the hook-lever at substation A is raised, so that the lamp K, in the re-ringing process, as before, serves to warn the operator if she fails to fully actuate the ringing plunger. In the present instance, the following values will be found to give satisfactory results: for direct current generator $B^3$, having its negative pole grounded, one hundred and twenty-five volts; and for battery B, having its positive pole grounded, twenty-four volts. The windings *a*, *b* and 64 may each be of two hundred and fifty ohms resistance. The winding of relay 61, and the non-inductive resistance connected between battery B and lamp 58, may each be of eighty-three ohms, while the left-hand winding of relay 62 and the shunting resistance for lamp 58 may be of forty ohms. The cut-off relays 53 of the lines may be of the usual resistance, approximating thirty ohms.

In the structure of Fig. 3, the removal of the receiver at H′ during the ringing interval will, as in the previous cases, avail to cause the relay 23 to permit the release of its armature mechanism.

Referring to Fig. 4, the telephone system there illustrated is quite similar in general arrangement to that of Fig. 3. Here, however, a relay 72 having a single winding is provided for controlling the connection and disconnection of the ringing mechanism. This relay is first operated on actuation of a plunger *p*, by current from ground through contact 39—38 to negative battery B, said relay then locking, by alternate contact 75, to ground at 59. The key lamp K is controlled in an obvious manner by the switch contact 75. While relay 72 is operated, the current from a connected generator G will flow through alternate contact 74, over the line limbs to H′, actuating the substation bell, returning through the sleeve talking contact at 54—69 and to the attracted armature 76, at which point, owing to the non-inductive shunt furnished by resistance 73 about the relay 72, the greater part of generator current will flow to ground through the circuit of battery B without passing through the winding of 72, so that said relay will not be deënergized by the ringing current. Assuming in the present case that the called subscriber responds during the silent interval, direct current from the generator $B^2$, having its negative pole grounded, will be connected through the raised hook-lever at the substation with attracted armature 76, at which point the current will divide, a part flowing to negative battery B, while the remainder will find its return through relay 72 to ground at 59. The potential thus produced at attracted armature 76 avails to oppose the current previously flowing through the relay 72 so that its core has its induced magnetism reduced to an extent such that its armature mechanism is restored to normal. That above indicated is a minimum requirement. Preferably, however, the resistances of the various devices are so proportioned that the connection of the source $B^2$ on the response from a line of relatively low resistance will serve to not only neutralize the core of relay 72, but to tend to build up therein a polarity opposite to that previously existing. By such reversal, a reliable throw-back of the armature mechanism is secured and at the same time an adequate margin is secured when the relay is to be operated by current over lines of high resistance, in which cases the potential at attracted armature 76 may not be sufficient to more than reduce the magnetism of the core of relay 72.

The detailed operation of the apparatus of Fig. 4 is sufficiently obvious from the description given in connection with Fig. 3 and need not be referred to more extensively. Removal of the receiver at H′ in the ringing interval will release the relay 72, since, because of the change of resistance at the substation, the generator current will at some period of its alternations substantially neutralize the direct current passing through said relay.

Values suitable for the structure of Fig. 4 are, for the battery B, having its positive pole grounded, twenty-four volts; for the direct current generator $B^2$, having its negative pole grounded, one hundred volts; for the winding of relay 72, five hundred ohms, and for non-inductive resistance 73, three hundred ohms, although of course other values may be employed.

It will be understood that the drawings are purely diagrammatic in character and no attempt has been made to indicate the precise mechanical embodiments of the various mechanisms.

That various changes may be made in the precise methods shown and described, is obvious. For instance, the use of polarized electromagnetic devices will readily suggest itself to those skilled in the art as a means adapted to secure a modified form of this invention; or the employment of so-called double-acting relays, in which a limited energization is produced to cause one operative position of the switch contacts, and a greater energization to produce another position of the switch contacts, would be a means likely to suggest itself to those desiring to practice my invention in modified form. Thus, in a general way, the present invention contemplates the use of a single relay which, in the first instance, is connected in closed circuit with a source of current to operate to connect ringing current with a line, whereafter an additional circuit is established for it to cause a further electromagnetic influence to be impressed upon it, whereby the relay opens the connection to the source of ringing current.

I claim as my invention:—

1. A telephone system including a telephone line, a connection for projecting signaling current thereover, a relay for closing and opening said connection, a circuit for initially energizing said relay, a connection controlled by said relay for locking it during signaling, a source of current, and a switch at the substation of said line for operation to conductively unite a pole of said source with said relay, said relay being then effective to open said connection.

2. A telephone system including a telephone line, a connection for projecting signaling current thereover, a switch contact included in said connection, a relay, means for effecting a flow of current through said relay to cause it to close said contact, and a switch connected in said telephone line and in circuit with said relay for effecting a different flow of current through said relay to cause it to open said contact.

3. A telephone system including a telephone line, a connection for projecting signaling current thereover, a switch contact included in said connection, a relay, means for effecting a flow of current through said relay to cause it to close said contact, a locking contact of said relay operated responsive to said flow to maintain said relay energized, and a switch connected in said telephone line and in circuit with said relay for effecting a different flow of current through said relay to cause it to open said contact.

4. A telephone system including a telephone line, a signaling source for connection therewith, switch mechanism, a relay serving when energized to operate said mechanism to connect said source to said line, and a circuit including a switch contact of said relay and the limbs of said telephone line for passing current through said relay to cause it to disconnect said source from said line.

5. A telephone system including a telephone line, a signaling source for connection therewith, switch mechanism, a relay serving when energized to operate said mechanism to connect said source to said line, and a circuit including the limbs of said telephone line for passing current through said relay to cause it to disconnect said source from said line.

6. A telephone system including a telephone line, a source of signaling current, a relay and switch mechanism actuated thereby when said relay is energized to connect said source and line, a locking circuit holding said relay energized during signaling, said telephone line having a substation connected in shunt of said locking circuit, and a substation switch controlling the line circuit adapted to pass current through said relay to cause it to alter the connections of said switch mechanism.

7. A telephone system including a telephone line, a connection for projecting signaling current thereover, a relay for closing and opening said connection, a circuit for initially energizing said relay, a connection controlled by said relay for locking said relay when it is initially energized, a winding for said relay, a source of current, and a switch at the substation of said line for operation to conductively unite a pole of said source to said winding, said relay being then effective to open said locking connection.

8. A telephone system including telephone lines, a link-circuit for interchangeable connection therewith, a source of current for connection with said link-circuit to signal a connected telephone line, a switch contact controlling connection and disconnection of said source and circuit, a relay, a circuit local to the exchange for effecting a flow of current through said relay to cause it to hold said contact closed, a locking switch contact of said relay included in said circuit, and a switch at the substation of a connected telephone line in circuit with said contact and adapted when closed to effect a different flow of current through said relay to cause it to open said contacts.

9. A telephone system including telephone lines, a link-circuit for interchangeable connection therewith, a source of current for connection with said link-circuit to signal a connected telephone line, a switch contact controlling connection and disconnection of said source and circuit, a relay controlling

said contact, a winding of said relay adapted to be energized by current local to the exchange to cause said relay to close said contact, a second winding for said relay connected with said telephone line in response to the energization of said first winding, and a switch in the connected telephone line for effecting an energization of said second winding to cause said relay to open said contact.

10. A telephone system including telephone lines, a link-circuit for interchangeable connection therewith, a source of current for connection with said link-circuit to signal a connected telephone line, a switch contact controlling connection and disconnection of said source and circuit, a relay controlling said contact, a winding of said relay adapted to be energized by current local to the exchange to cause said relay to close said contact, a second winding for said relay, and a hook-switch in the connected telephone line effective on a response thereover to energize said second winding in opposition to said first winding, whereby said relay opens said contact.

11. A telephone system including telephone lines, a link-circuit for interchangeable connection therewith, a source of current for connection with said link-circuit to signal a connected telephone line, a switch contact controlling connection and disconnection of said source and circuit, a relay controlling said contact, a winding of said relay adapted to be energized by current local to the exchange to cause said relay to close said contact, a second winding for said relay connected responsive to the energization of said first winding with said telephone line, and a hook-switch in the connected telephone line effective on a response thereover to energize said second winding in opposition to said first winding whereby said relay opens said contact.

12. A telephone system including telephone lines, a link-circuit for interchangeable connection therewith, a source of current for connection with said link-circuit to signal a connected telephone line, a switch contact controlling connection and disconnection of said source and circuit, a relay having two windings and controlling said contact, means for initially energizing said relay to close said contact, conductors for said link-circuit in circuit with the limbs of one of said lines and extended to connection with said windings respectively by the energization of said relay, connections for passing current from said signaling source over said telephone line and differentially through said windings, said relay being unresponsive to the signaling currents, and a switch at the substation adapted on response to close a conductive circuit through said second winding whereby said relay receives current to operatively neutralize said first winding.

13. A telephone system including telephone lines, a link-circuit for interchangeable connection therewith, a source of current for connection with said link-circuit to signal a connected telephone line, a switch contact controlling connection and disconnection of said source and circuit, a relay having two windings and controlling said contact, means for initially energizing said relay to close said contact, a locking circuit completed by the energized relay to maintain it in closed circuit, said locking circuit including one of said windings, conductors for said link-circuit in circuit with the limbs of one of said lines and extended to connection with said windings respectively by the energization of said relay, connections for passing current from said signaling source over said telephone line and differentially through said windings, said relay being unresponsive to the signaling currents, a switch at the substation adapted on response to close a conductive circuit through said second winding, and a resistance at the exchange connected in circuit with one of said windings and proportioned to adjust the flow of current through said windings on the response to operatively demagnetize said relay.

14. A telephone system including telephone lines, a link-circuit for interchangeable connection therewith, a source of current for connection with said link-circuit to signal a connected telephone line, a switch contact controlling connection and disconnection of said source and circuit, a relay having two windings and controlling said contact, means for initially energizing said relay to close said contact, conductors for said link-circuit in circuit with the limbs of one of said lines and extended to connection with said windings respectively by the energization of said relay, connections for passing current from said signaling source over said telephone line and differentially through said windings, said relay being unresponsive to the signaling currents, a switch at the substation adapted on response to close a conductive circuit through said second winding, and a resistance at the exchange connected in circuit with one of said windings and proportioned to adjust the flow of current through said windings on the response to operatively demagnetize said relay.

15. A telephone system including telephone lines, a link-circuit for interchangeable connection therewith, a source of current for connection with said link-circuit to signal a connected telephone line, a switch contact controlling connection and disconnection of said source and circuit, a relay having two windings and controlling said

contact, means for initially energizing said relay to close said contact, a locking circuit completed by the energized relay to maintain it in closed circuit, said locking circuit including one of said windings, conductors for said link-circuit in circuit with the limbs of one of said lines and extended to connection with said windings respectively by the energization of said relay, connections for passing current from said signaling source over said telephone line and differentially through said windings, said relay being unresponsive to the signaling currents, a switch at the substation adapted on response to close a conductive circuit through said second winding and an inductive device connected in shunt of said first winding and offering high impedance resistance to the signaling currents, said device being proportioned to adjust, upon response at the substation, the current flow through said windings to operatively demagnetize said relay.

16. A telephone system including telephone lines, a link-circuit for interchangeable connection therewith, a source of current for connection with said link-circuit to signal a connected telephone line, a switch contact controlling connection and disconnection of said source and circuit, a relay having two windings and controlling said contact, means for initially energizing said relay to close said contact, a locking circuit completed by the energized relay to maintain it in closed circuit, said locking circuit including one of said windings, conductors for said link-circuit in circuit with the limbs of one of said lines and extended to connection with said windings respectively by the energization of said relay, connections for passing current from said signaling source over said telephone line and differentially through said windings, said relay being unresponsive to the signaling currents, a switch at the substation adapted on response to close a conductive circuit through said second winding, an inductive device connected in shunt of said first winding and offering impedance to the signaling currents, said device being proportioned to adjust, upon response at the substation, the current flow through said windings to operatively demagnetize said relay, and an armature released upon such demagnetization to effect disconnection of said windings and said conductors and the opening of said locking circuit.

17. A telephone system comprising a telephone line extending from a central station to a substation, a call-receiving device and a hook-switch at the substation, calling apparatus at the central office, a relay operating on energization to put said calling apparatus to line, and a contact of said switch-hook for closure in circuit with said relay, controlling its energization to disconnect said calling apparatus.

18. In a telephone system, a telephone line extending from a central station to a substation, a call-receiving device and a hook-switch at the substation, calling apparatus at the central office, a relay operating on energization by current local to the exchange to put said calling apparatus to line, and a contact of said switch-hook for closure in circuit with said relay, controlling its connections to cause it to disconnect said calling apparatus.

19. In a telephone system, a telephone line extending from a central station to a substation, a call-receiving device and a hook-switch at the substation, calling apparatus at the central office, a relay operating on energization to put said calling apparatus to line, and a contact of said switch-hook for closure in circuit with said relay, adapted to control it to disconnect said calling apparatus.

20. In a telephone system, a telephone line extending from a central station to a substation, a call-receiving device and a hook-switch at the substation, calling apparatus at the central office, a relay operating on energization by current local to the exchange to put said calling apparatus to line, and a contact of said switch-hook in circuit with said relay for closure to cause said relay to disconnect said calling apparatus.

21. A telephone system including a telephone line extending from a central station to a substation, a call-receiving device and a hook-switch at the substation, calling apparatus at the central office, a relay operating on energization to put said calling apparatus to line, and a contact of said switch-hook for closure in circuit with said relay, controlling its connections to cause it to disconnect said calling apparatus.

22. A telephone system including a telephone line extending from a central station to a substation, a call-receiving device and a hook-switch at the substation, calling apparatus at the central office, and a relay operating on energization to connect said calling apparatus to line and directly actuated by current in said line to disconnect said calling apparatus.

23. A telephone system including a telephone line extending from a central station to a substation, a call-receiving device and a hook-switch at the substation, calling apparatus at the central office, and a relay directly operated by current to connect said calling apparatus to line and directly operated by current in the line to disconnect said calling apparatus.

24. A telephone system including a telephone line extending from a central station to a substation, a call-receiving device and a hook-switch at the substation, calling ap-

paratus at the central office, and a relay directly operated by current controlled at the exchange to connect said calling apparatus to line and directly operated by current through the substation to disconnect said calling apparatus.

25. In a telephone system, a telephone line extending from a substation to the exchange, a signal-receiving device and a switch, at the substation, signal-actuating apparatus, a relay, a circuit adapted when closed to produce and maintain an initial energization of said relay, a switch contact of said relay actuated in response to said initial energization to connect said line with said relay, a source of current to produce a different energization of said relay on the closing of said substation switch, and a switch contact of said relay actuated in response to said initial energization to connect said apparatus to said line and to said different energization to disconnect said apparatus from said line.

26. In a telephone system, a telephone line extending from a substation to the exchange, a signal-receiving device and a switch at the substation, signal-actuating apparatus, a relay, a circuit local to the exchange adapted when closed to produce and maintain an initial energization of said relay, a source of current to produce a different energization of said relay on the closing of said substation switch, and a switch contact of said relay actuated in response to said initial energization to connect said apparatus to said line and to said different energization to disconnect said apparatus from said line.

27. In a telephone system, a telephone line extending from a substation to the exchange, a switch at the substation, signal-actuating apparatus, a relay, two windings for said relay, means for initially energizing said relay by closing a circuit local to the exchange through one winding of said relay, a source of current to produce a different energization of said relay on the closing of said substation switch by passing current through said other winding, and switch mechanism of said relay actuated in response to said initial energization to connect said apparatus to said line and to said different energization to disconnect said apparatus from said line.

28. A telephone system including a telephone line extending from a substation to the exchange, a switch at the substation, signal-actuating apparatus, a relay, a circuit to initially energize said relay, a switch contact of said relay actuated in response to said initial energization to connect said line with said relay, a source of current to produce a different energization of said relay on the closing of said substation switch, and a switch contact of said relay actuated in response to said initial energization to connect said apparatus to said line and to said different energization to disconnect said apparatus from said line.

29. In a telephone exchange system, the combination with a telephone line extending to an exchange, of a substation switch-hook, an electromagnet connected in a controlling circuit, a first branch of said circuit, a second branch of said circuit including a contact of said switch-hook, means whereby current in only the first branch causes one energization of said magnet and current in both branches causes a different energization of said magnet, and calling apparatus at the exchange connected to line by operation of said magnet in response to said one energization and disconnected from line by the operation of said magnet in response to said different energization.

30. In a telephone exchange system, the combination with a telephone line extending to an exchange, of a substation switch-hook, an electromagnet connected in a controlling circuit, a first branch of said circuit, a second branch of said circuit including a contact of said switch-hook, means for causing current in the first branch to cause one energization of said magnet, means controlled by said contact to close a circuit of said second branch to cause a different energization of said magnet, and a connection for operatively establishing ringing current to line, said connection being closed by said one energization and later opened by said other energization.

31. In a telephone exchange system, the combination with a telephone line extending to an exchange, of a substation switch-hook, an electromagnet connected in a controlling circuit, a first branch of said circuit, a second branch of said circuit including a contact of said switch-block, means for causing current in the first branch to cause one energization of said magnet, means controlled by said contact to alter said circuit so that current flows in both branches to produce a different energization of said magnet, and calling apparatus at the exchange connected to line by operation of said magnet in response to said one energization and disconnected from line by the operation of said magnet in response to said different energization.

32. In a telephone exchange system, the combination with a telephone line extending to an exchange, of a substation switch-hook, an electromagnet connected in a controlling circuit, a first branch of said circuit, a second branch of said circuit including a contact of said switch-hook, means whereby current in only the first branch causes one energization of said magnet and current in both branches causes a different energization of said magnet, and a connection for

operatively establishing ringing current to line, said connection being closed by said one energization and later opened by said other energization.

33. A telephone system including a terminal contact, a link-circuit having a connection device adjustable to connection with said contact, signal actuating means associated with said circuit, a switch for actuation to cause connection of said means with said circuit, a signal for said switch actuated in response to connection of said device with said contact, means for altering the indication of said signal when said switch is actuated, and means for maintaining the altered indication when said switch is restored.

34. The combination with a telephone line, of an operator controlled connection device adapted for adjustment to connection with said line, a switch for applying calling current to said line, a signal for said switch sensitive to connection of said device and line, means for retiring said signal when said switch is actuated, and means for preventing restoration of said signal on restoration of said switch.

35. In a telephone system, the combination with a telephone line, of an operator's link-circuit having a normally open contact in the talking circuit and connected with said line, signal-actuating apparatus for said circuit in operative relation with said line, a relay controlled over the line circuit for terminating said relation, a supervisory relay controlled through contacts of said relay, and an armature for said supervisory relay for directly closing said normally open contact when said relation is terminated.

36. In a telephone system, the combination with a telephone line, of an operator's link-circuit having a normally open contact in the talking circuit and connected with said line, signal-actuating apparatus for said circuit in operative relation with said line, a relay controlled by a response over said line for terminating said relation, and a second relay adapted to be operated by current over said telephone line for closing said normally open contact in response to the operation of said relay.

37. In a telephone system, a pair of telephone lines, a link-circuit connected to said lines, a repeating coil interposed between said lines in a circuit normally inductively discontinuous at the exchange, signal-actuating apparatus, a switch and associated relay operative to associate said apparatus with one of said lines while leaving said repeating coil circuit inductively discontinuous at the exchange, a second relay controlled by said first relay and operative by current over one of said lines to render said repeating coil circuit inductively continuous at the exchange.

38. In a telephone system, telephone lines, a link-circuit normally inductively discontinuous at the exchange, a repeating coil interposed in said link-circuit, means for connecting the opposite ends of said link-circuit each to a different line while leaving said link-circuit inductively discontinuous at the exchange, ringing apparatus and an operator's key for said circuit for actuation to operatively associate said apparatus with a connected line while leaving said link-circuit inductively discontinuous at the exchange, means controlled over said connected line to terminate the operative association of the ringing apparatus therewith, and a device for rendering said link-circuit inductively continuous at the exchange after operation of said means.

39. In a telephone system, two connected telephone lines, a repeating coil circuit interposed between said lines and normally inductively discontinuous at the exchange, ringing apparatus and an operator's key for actuation to operatively associate said apparatus with one connected line while leaving said repeating coil circuit inductively discontinuous at the exchange, means controlled over said one line to terminate the operative association of the ringing apparatus therewith, and a supervisory relay operating in response to said means to render said repeating coil circuit inductively continuous at the exchange.

40. A telephone system including two connected telephone lines, a ringing generator, a switch adapted when actuated to effect connections including the ringing generator in circuit, a repeating coil interposed between said lines in an inductively discontinuous circuit, and electromagnetic means operated when the substation telephone is removed from the hook to restore said switch and to render said circuit inductively continuous.

In witness whereof, I hereunto subscribe my name this 24th day of Nov., 1908.

HARRY G. WEBSTER.

Witnesses:

CAROLYN WEBER,

G. E. MUELLER.